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15 May 1976

THEMATIC MAPPING, LAND USE, GEOLOGICAL STRUCTURE AND WATER RESOURCES IN CENTRAL SPAIN

Project no. 28760

SECOND QUARTERLY REPORT

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15 May 1976

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Second Quarterly Report

ORIGINAL CONTAINS COLOR ILLUSTRATIONS

Original photography may be purchased from:
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

Contributing Organizations:

- Centro de Estudios Hidrográficos del Ministerio de Obras Públicas
- Instituto de Geografía Aplicada del Consejo Superior de Investigaciones Científicas
- Instituto de Edafología del Consejo Superior de Investigaciones Científicas
- Cátedra de Geodinámica Interna de la Universidad Complutense de Madrid
- Cátedra de Geografía de la Universidad Complutense de Madrid
- Centro de Investigación UAM-IBM de la Universidad Autónoma de Madrid
- Instituto Geográfico y Catastral.

THEMATIC MAPPING, LAND USE, GEOLOGICAL STRUCTURE AND WATER RESOURCES IN CENTRAL SPAIN.

Project no.28760

I. INTRODUCTION

Project no.28760 has continued in a closed cooperation between participating organizations. Some anticipated results are submitted for this Second Quarterly Report, mainly in the areas of geology, land use and soil mapping. Application to specific scientific fields has been accompanied by development of new methodologies or working techniques in the contributing agencies.

II. TECHNIQUES

New images have been received from NASA through EROS Data Center for completion of the project. Products received are:

- black and white negatives in 70 mm film, all four bands MSS, scale 1:3.369.000.
- black and white paper prints, all four bands MSS, scale 1:1.000.000

Reproduction work of the images for distribution to participating agencies was done in B/W paper at scale 1:500.000, all four bands MSS. Contact positives in 70 mm film have also been obtained for analysis through the color composite viewer.

Some sucessful research has been carried out at Instituto Geográfico y Catastral (IGC) for obtaining false color paper prints at scale 1:1.000.000 from the original NASA CCT's. This was done with the DICOMED film recorder producing a color positive image in 70 mm format, which was enlarged at the above mentioned

scale with Cibachrome material. Results obtained show a high quality of this product for interpretation purposes, and enlarged copies at scale 1:250.000 will be provided to participating agencies in the next few weeks. Required reformating of NASA tapes was done by IBM Scientific Center of the Autonomous University of Madrid, in order to provide the DICOMED D-47 film recorder with an acceptable input CCT data format.

The Remote Sensing Laboratory of IGC has started the field work. The selected test site for recognition of natural and man made features was Aranjuez area, at 30 milles distance from Madrid. In this place has been done a multispectral aerial flight in May 15, 1976, with a 10 channel Daedalus scanner (visible and near infrared). Anticipated results and characteristics of the operation will be announced in the Third Quarterly Report. Measurements done at the same time of observation by the airplane included:

- water quality in Jarama and Tajo rivers
- phenological state of crops
- soil identification
- urban and man made constructions.

This test site was flown during the year 1975 by COPLACO, and an extensive photointerpretation work will be used as ground truth for study of satellite imagery. Two LANDSAT-1 CCT's from 1973 are also available, and it is expected to obtain good results in land use classification and crop change detection over the area. At the moment, a LANDSAT-2 CCT has been requested to NASA for study of the zone and correlation of information obtained from satellite, airplane and field check.

The flight was done for this project, as part of the existing agreement between the french Centre National d'Etudes Spatiales and the Spanish Comisión Nacional de Investigación del

Espacio. Airplane used was a CASA-212 from Instituto Nacional de Técnica Aeroespacial, flying at 500 m above mean ground elevation. Simultaneously to the operation of the multispectral scanner, four Hasselblad cameras f 2'8/50 mm obtained multiband aerial photography with the following films:

- Panatomic - X 3410
- Black & White Infrared 2443 Aerochrome
- Color Infrared 2424

Ground truth of multiband photography was also obtained with wratten gelatin filters, using Panatomic - X and Plus - X Pan films. For differentiation of features in narrow bandpass radiation, it was observed that higher sensitivity of Plus - X Pan film provided better results in the ground than Panatomic-X film, which in turn has the necessary higher contrast for aerial recognition.

III. ACCOMPLISHMENTS

Upon request of IGC, future dates of LANDSAT-2 observations over Spain have been provided by NASA. This allows recognition of test sites the same day of overpass by the satellite, at the same local solar time, for reflected radiation comparison at ground and orbital levels. By the end of June, the spectroradiometer will be used for this purpose. Until the moment, the schedule of observations comprises the following areas for next June:

- Reservoir of El Burguillo
- Reservoir of Entrepeñas
- Aranjuez Test Site
- Hoya de Villalba Test Site.

This work will be done in coordination by several of the participating agencies.

Because all existing coverage of good quality obtained by LANDSAT-1 and LANDSAT-2 over Spain has been acquired and received by IGC, it is intended to use the 70 mm negatives for enlargement at scale 1:1.000.000 in black and white, and formation of a national mosaic at scale 1:1.000.000 in band 7.

Updating of Provincial Maps at scale 1:200.000 has not yet begun in operational manner, but the first studies show that LANDSAT information will be very useful for modernizing the following items:

- transportation network, urban and rural highways
- forests, mainly fast growing species
- reservoirs and rivers layout.

Land-use classification has started by studying a test site North of Madrid. All available information, once digitized, will be used as training input for the computer, and it is expected to extrapolate results for classification of the Central Region of Spain.

IV. SIGNIFICANT RESULTS

This section contains all the contributions from participating agencies. In some cases, some anticipated results have been obtained; in other cases, reports are an indication of progress done in the investigation, with no anticipated results. Because the multidisciplinary character of this project, covering varied scientific fields, all contributions are presented separately. Results obtained by recognition of forest desease will be announced in the third Quarterly Report.

LOCALIZATION OF A GREAT STRUCTURE IN IBERIAN PLATEAU: THE ESTREMENIAN-CASTILIAN VAULT

By Manuel Alía
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SPAIN

I. INTRODUCTION

From the study of LANDSAT images in bands 5 and 7 over central region of Iberian plateau, and based on geological knowledge of the area, it has been established the existence of a great vault in such region. This feature has been named "Estremenian-Castilian vault", because it comprises great part of both Castillas and Extremadura. Major axis goes from Badajoz towards NE, with a length superior to 350 kms.

This lithospheric megastructure is in practice divided in two parts by intersection of the structures with general direction E-W forming part of the previously named "Structural band of Toledo" (Alía, M., 1972).

The megastructure developed in regions where Hercynian materials and more ancient basements are upwelling, and in areas where this old unit remains covered by latter sedimentary covers, mainly tertiary. Defining elements of the megastructure in both types of regions are different.

In the case of uncovered basements, they are noticed mainly by fractures with preferential alignements and relative continuity showing the major structure to which correspond. Many of these fractures are used by the actual fluvial network. In the domain of upwelling basements some aligned bands of sediments can be found. In the case of areas with sedimentary cover, elements equally aligned are present, corresponding and reflecting,

through the surface cover, existing alignements of the occult basement, depending on already established correlations for the area of the Tectonic basin of Tajo (Alía, M., 1960; Alía, M., et al., 1973; Cadavid, S., et al., 1967 and Martín Escorza, C., et al., 1973). Such alignements in the cover can be expressed by side changes of facies and powers, by deformations equally aligned in the sediments, by morphological depressions and, also, by the current trench of hydrographic network, which in many cases presents equally aligned sections conditioned by the accidents of the basement placed below.

Figure 1 corresponds to an old image taken by LANDSAT-1 over Central region of Spain in band 7. In figure 2 it has been established, eschematically, the main structural alignement that forms the Estremenian-Castilian vault, whose northern unit appears represented in the image. In figure 2 it has been signaled also the approximate orientation E-W of the structures existing in the area and forming part of the above mentioned "Structural band of Toledo". Looking for a major clearness, only the main estimated structural elements have been signaled, although some other features as the southern and radial fractures located in the Avila-Segovia area, or the N-NW alignements between Avila and Salamanca, can also be noticed.

In figure 3 have been represented, with eschematic character, the main fractures which, according to the interpretation, define the Estremenian-Castilian vault. It can be observed the influence that mentioned Band of Toledo has on the outline and definition of the vault, which is divided in two units; the northern, with numerous arching alignements, and the southern, with a minor accidental topography and a limited number of defining structures.

Formation of the vault should be probably situated in the Oligocene-Miocene times and was influenced, in great part,

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Figure 1

8a

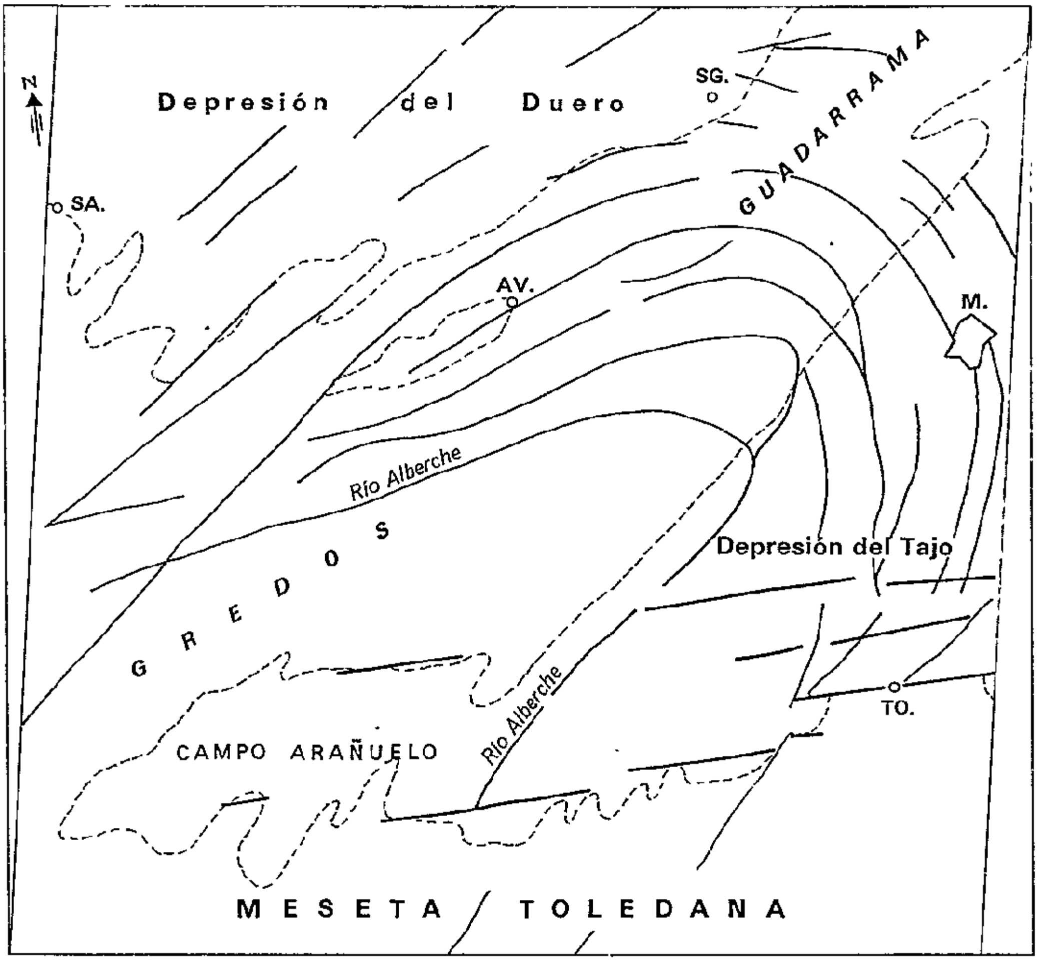

Figure 2—Eschematic representation of some of the main structures of fig. 1. In white: areas of upwelling basements, in gray: areas of cover. Continuous lines along Alberche river. alignements corresponding to the Estremenian-Castilian vault. Lines oriented E-W: alignements corresponding to the Structural Band of Toledo.

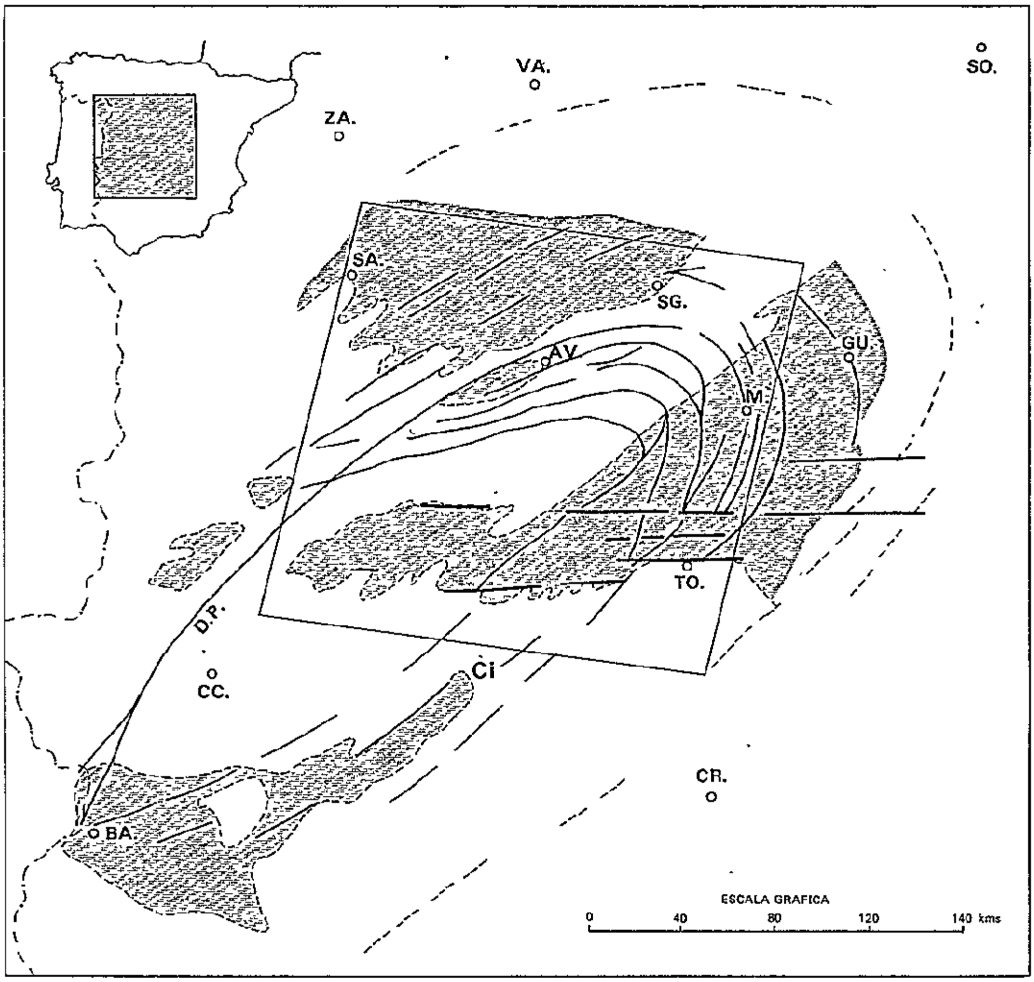

Figure 3.—Main structural alignements defining the Estremenian-Castilian vault, which appears in practice divided in two parts by E-W alignements of the Structural Band of Toledo. In gray: main areas of cover related to the vault. Outlines represented probable structural alignements more peripheric. Inthe center of the image, squared area corresponds to the one represented on figures 1 and 2, with the same symbols for the capitals. Za: Zamora, Va: Valladolid, So: Soria, Gu: Guadalajara, Cr: Ciudad Real, Cc: Cáceres, Ba.-Badajoz, Ci: Cíjara and D. P : Plasencia dike.

by the existence of more ancient structural directives. After an early phase of generalized elevation should follow another of collapse in the flanks, preferably in the northern half vault. It seems also that differential movements have continued until recent times, as it can be deduced, for example, from morphology and adaptation of many sections of the actual fluvial network to directives of the vault in the areas of cover. In figure 4 is reproduced a part of the Bouguer Anomaly Map of the Iberian Peninsula, executed by the Hawaii Institut of Geophysics in 1966. Some of the isoanomalies of this map correspond to structures of the Estremenian-Castilian vault and the Structural Band of Toledo. A major complexity and irregularity in the distribution of isoanomalies is also observed on the northern half vault, where a more accidental an structural complexity exists. It could be interpreted that owing to continuation of differential movements until recent times, isostatic equilibrium in these areas has not been attended.

As previous hypothesis on possible origin of the vault it is supposed that it was generated by a side compression of the lithosphere, or by activation of the underneath layer. In this second assumption it could be thought in the existence of a plume of the layer, or also in displacements or side transmissions in the layer, from a marginal area more active.

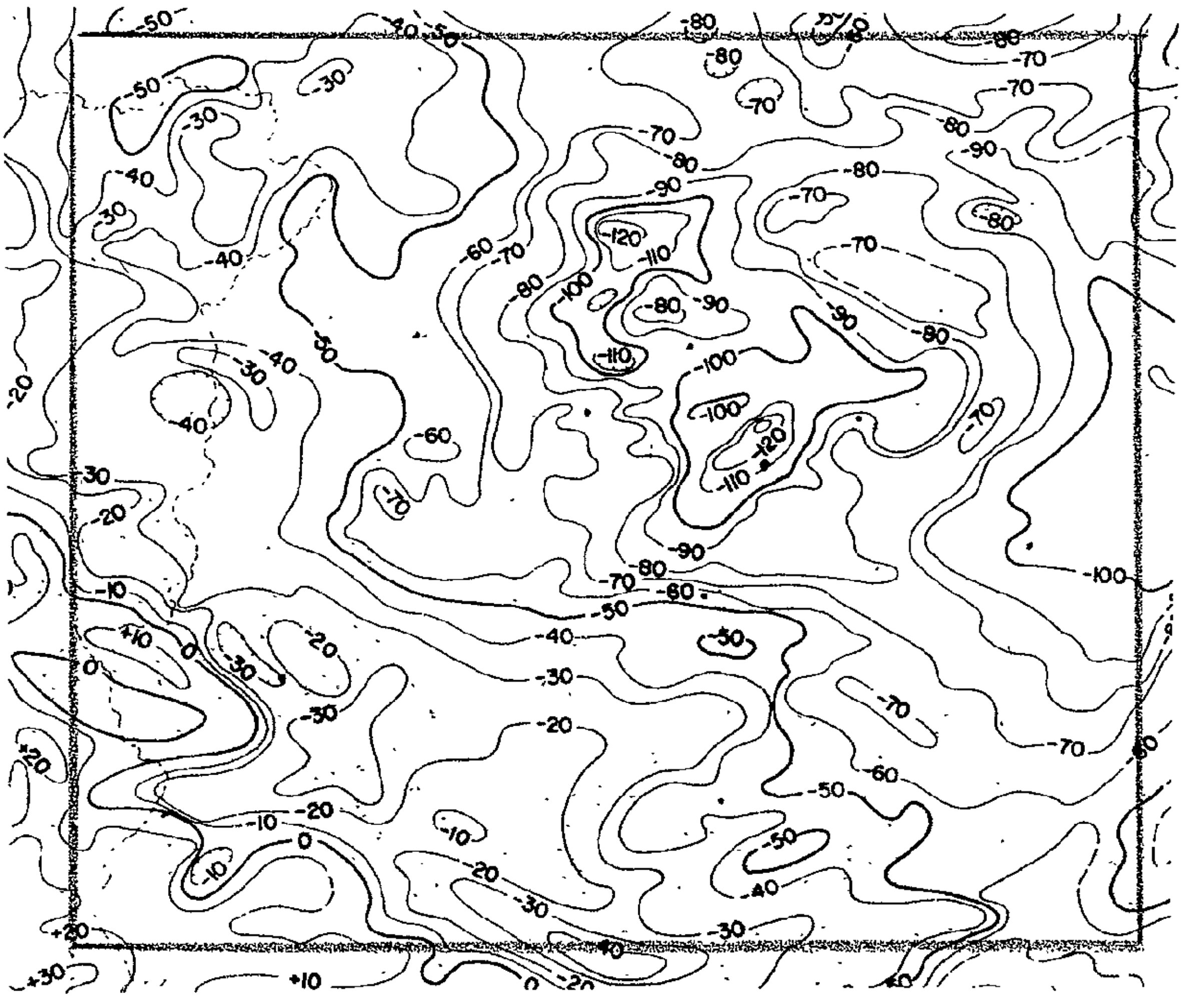

Figure 4.—Central area of Bouguer Anomalies Map of Iberian Peninsula, executed by the Hawaii Institute of Geophysics, 1966 Contour interval = 10 mgals. Same symbols for capitals than in figures 1, 2 and 3 Furthermore, Cu: Cuenca

POSSIBILITIES OF APPLICATION OF BAND-RATIO TECHNIQUE TO THE GEOLOGICAL FEATURES OF THE WESTERN LIMIT OF THE TAJO BASIN

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Universidad Complutense de Madrid
SPAIN

I. GEOLOGICAL LAYOUT AND SITUATION OF THE ZONE

The region under study is situated to the west of Talavera de la Reina, and includes part of the provinces of Caceres and Toledo. Geologically, it is the western limit of the Tajo fault Basin, and as result of our studies in the area, we deduced a certain autonomy in its evolutive behaviour during the Tertiary era, which along with its particular lithological characteristics, leads us to consider it as a sub-basin within the larger one of the Tajo, and which we will call "Campo Arañuelo Basin". It is limited by the approximation of the paleozoic borders in Talavera to the east; by the closure of the valley to the west, in the area surrounding "La Bazagona"; by the "Sierra de Gredos" to the north and by the "Montes de Toledo" to the south.

We have got two perfectly distinguishable and well defined lithological entities: the paleozoic basement, which forms the massifs of the border, and acts as a rigid unit in the recent dynamic processes, and the tertiary cover rocks, which fills the large, central tectonic depression.

The basement is composed of igneous and metamorphical rocks of a very varied nature, ranging in date from the Precambrian to the Devonian.

The tertiary covering is exclusively detritic, with basal conglomerates, arkose and argillarenaceous rocks unevenly distributed by the frequent changes in facies.

The predominance of the arkose is evident, outcropping in the central plain of the basin, with intercalations of no great magnitude.

Amongst the structures present in the area, we emphasize, because of their more detailed study and in order to refer to them later, those existing in the southern border (Montes de Toledo), and which stand out in the tertiary plain with topographical and geological individuality. These three units (Fig. 1 and 2), are, from east to west, named "unidad de Oropesa", "unidad de Berrocalejo", and "unidad de Navalmoral", affording from their study fundamental data for the dynamic interpretation of the zone.

They amount to three paleozoic blocks composing igneous and metamorphical rocks, of similar geometry and with an evident orientation of their major axis in the direction NE-SW, being limited to the north and the west by inverted faults of rectilinear outline and with a fault-plane visible in the terrain (fig.3). The units, in their interior, are heavily fractured, and from the detailed study of this fracturing three directions of maximum frequency can be deduced, which coincide plainly with the interpretations of this central region of Spain. The directions are E-W, NE-SW and NNE-SSW. These fractures, the result of previous orogenesis, were reactivated in the Tertiary era, within the style of a fault-blocks scheme which corresponds with the dynamic pattern of the zone.

The northern border of the fault-valley is formed by the basement outcropping on the right-hand bank of the Tietar River. The presence of faults in this border must be indicated, as well as recent dynamics: Valle del Tiétar, Jarandilla-Candeleda, etc. Similar units are not apparent as the southern border.

The eastern border is formed by the narrowing of the fault-basin, represented topographically by the approximation


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N040-30
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11JUL75 C N40-22/W004-42 N N40-22/W004-38 MSS 7 R SUN EL58 AZ115 191-2366-A-1-N-D-1L NASA ERTS E-2170-10204-7 01
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Figure 1

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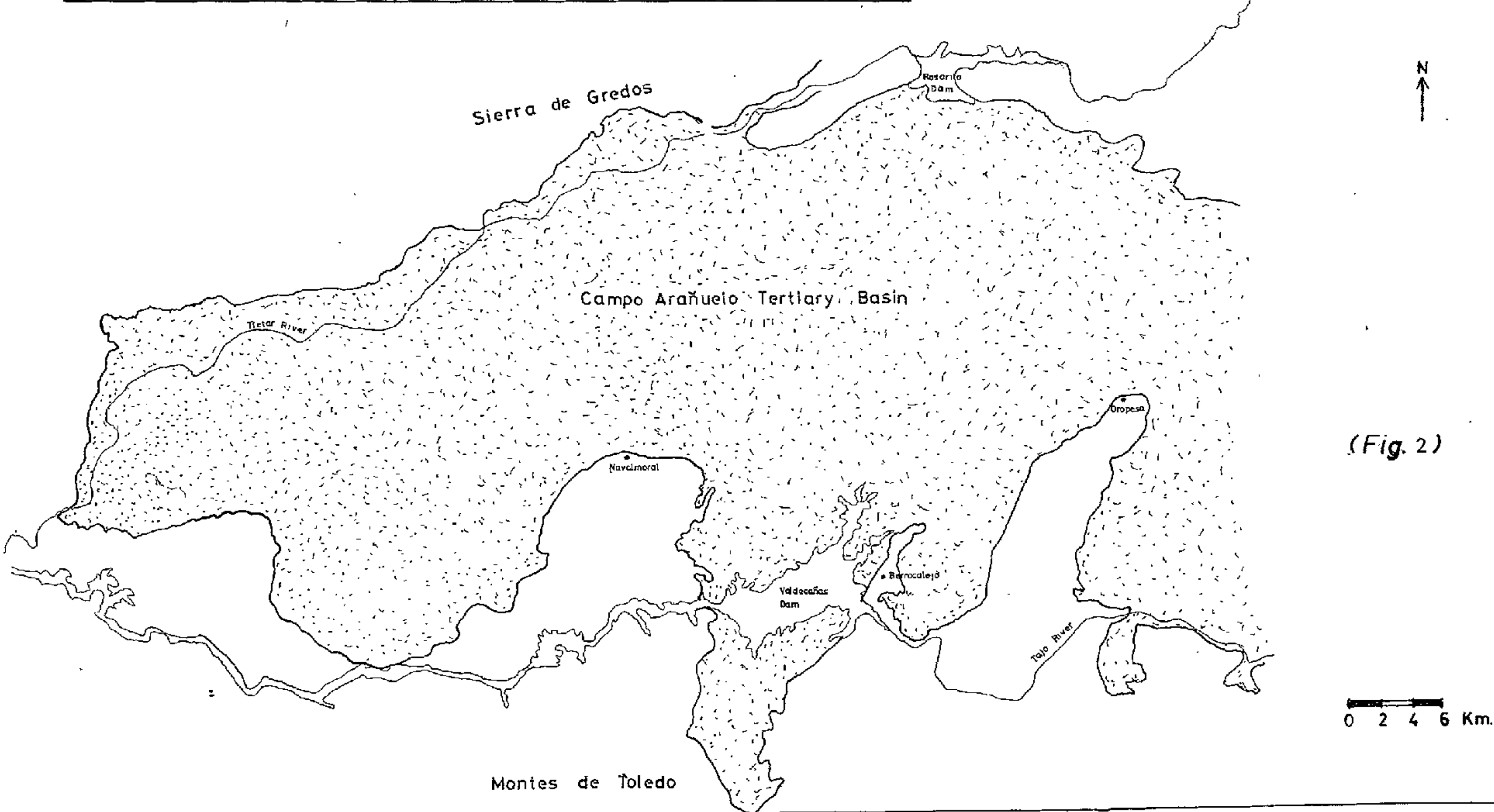
Basement-Tertiary distribution defined from I.G.M.E. maps



(Fig. 2)

of the paleozoic borders and stagings of deep origin as shown by its recent geophysical and geotechnical studies.

The western border is formed by the cambrian slate ranges near the outlet of the Tietar river into the Tajo. The folded structures are of a NW-SE direction, equal to that of the Montes de Toledo to the southern of the fault-valley.

II. STUDY OF THE MSS IMAGES

II.1.- Characteristics of the analised image

The Landsat MSS, as it is known, takes each of the multispectral at 6 bits, the first three in logaritmic scale and the fourth in linear scale. NASA processes the tapes and distributes them in such a way that the first three result in linear scale in 7 bits, and the fourth in linear scale and 6 bits, with no change.

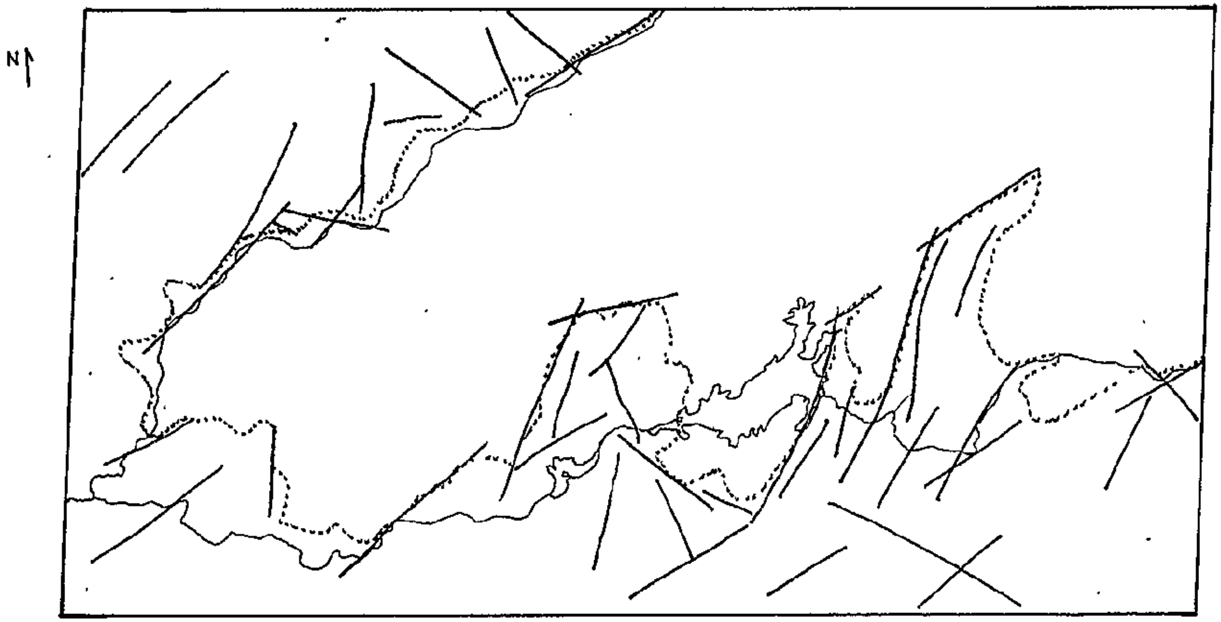
This calibration is made dynamically during each display using the calibratory data, in such a way that the correspondence transforming the bands taken by the Landsat varies from zone to zone (GONZALEZ, J., 1976). In the first images processed by NASA, the presence of errors was apparent. Because of this, in the image which we studied, there exists a line that contains, to an extent, incorrect data, in band 7 (the bits are of FF exadecimal value).

The images distributed by NASA encompass dimensions of 185x185 km., and have 3240 pixels in the horizontal and 2340 in the vertical. This determines that the pixel should be a rectangular plot and that the horizontal and vertical scales should not be the same. The data of the display studied:

- Date: 8 March 1973
- Image nº: 1228-10325
- Solar Elevation: 37º
- Azimut: 142º

CUENCA DE CAMPO ARAÑUELO

lineaments and Basement-Tertiary distribution as interpreted from the Landsat-1 imagery



...... Basement - Tertiary contact

—— fractures and faults

Tajo (with Valdecañas dam) and
Tietar rivers are represented

E 2170
11 Jul 75
MSS 5

fig. 3.

0 5 10 15 Km

II.2.- Characteristics of the Terminal employed

The process which we have followed, and will later explain, was carried out with an interactive RAMTEK Terminal connected to an IBM 360-65. The Terminal comprises a conversational screen and another for images (Colour-TV), as well as a memory bank to accumulate images at 8 bits, with 16 levels in each of the three tubes. The entire system is governed by the ER-MAN II programme. (Figure 4).

The colour images obtained are the result of the following process: A histogram is made of the radiation levels in each of the bands to be represented and the levels are assembled in 8 grades of intensities for the red and green and four grades for the blue. This assembly is made in such a way that there are approximately the same number of pixels in each, this condition is imposed for the maximisation of the information.

II.3.- Study of the Landsat image

The principle objective of this analysis is to verify the possible applications of the band-ratio technique for geological observations. Because of this we have begun with a zone well known in its lithological and structural characteristics and we have operated with the RAMTEK Terminal in order to determine which ratio of channels best results for the visualisation of such characteristics.

In a previous period of bibliographical consultation, we estudied the ratios employed by different authors. Logically these ratios have been applied to areas which, in the majority of cases, bear no relation to ours (volcanic, etc), but they have served us a basis for the development of new types. We wish to insist that the determination has been made on the grounds of geological character without dwelling on the validity of the ratios for other purposes (forestry, etc.).

Figure 4

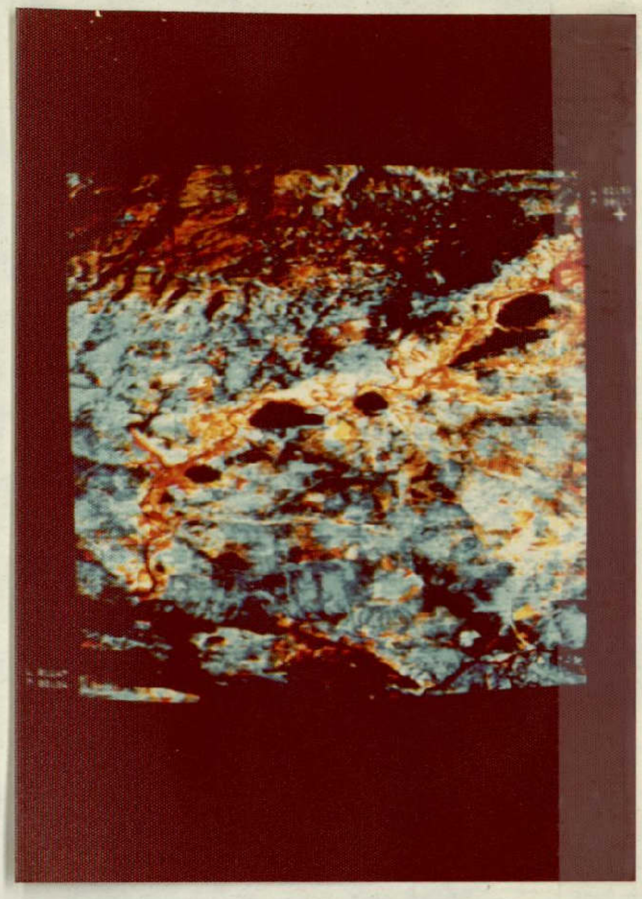


Figure 5

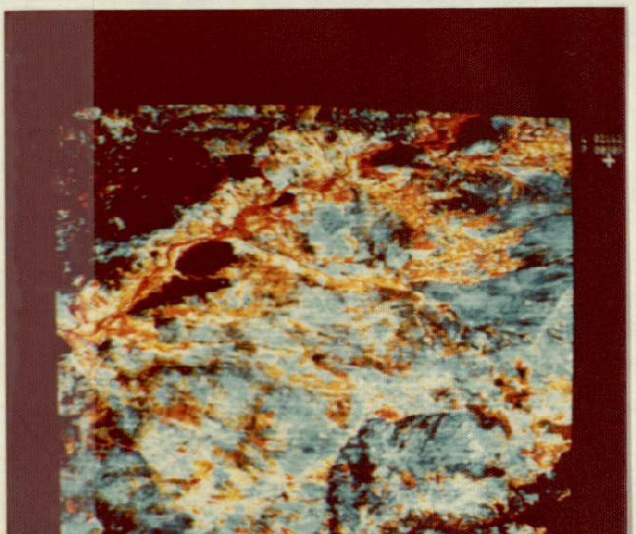


Figure 6

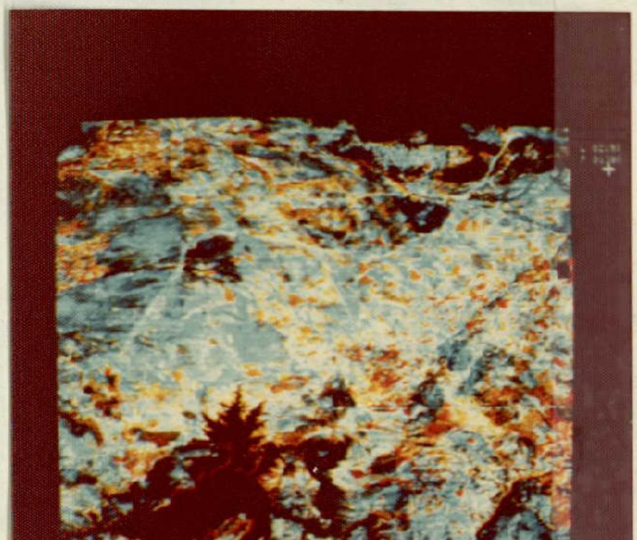


Figure 7

On the grounds of this determinative we examined at length some 40 combinations of band-ratios. Starting with the grey levels, we saw that they did not afford us valid information, given that it was always appreciably inferior to that provided by the whole bands (4,5,6,7), although the reference of Lovegreen et al. (1975), cites the ratio 5/4 as optimum for areas of extensive vegetal covering with respect to lithological differentiation, but we believe that our area does not resemble these characteristics.

In false colour, we consider as best for the observation of lithologies and linear structures the following combinations of ratios:

-a) R 4 G 7 B 7/4 (fig. 5,6,7)

which are given by the following coefficients:

R $I'_1=I_4$

G $I'_{13}=I_7$

B $I'_{14}=64\ I_7/(I_4+1)$

-b) R 4 G 7/4 B 7

given by:

R $I'_1=I_4$

G $I'_{14}=64\ I_7/(I_4+1)$

B $I'_{13}=I_7$

These are, in our opinion, the best combinations for the observation of the Basin which concerns us. The following are also valid:

-c) R 4 G 7/4 B 7/5 (fig.8)

given by:

R $I'_1=I_4$

G $I'_{14}=64\ I_7/(I_4+1)$

B $I'_{15}=64\ I_7/(I_5+1)$

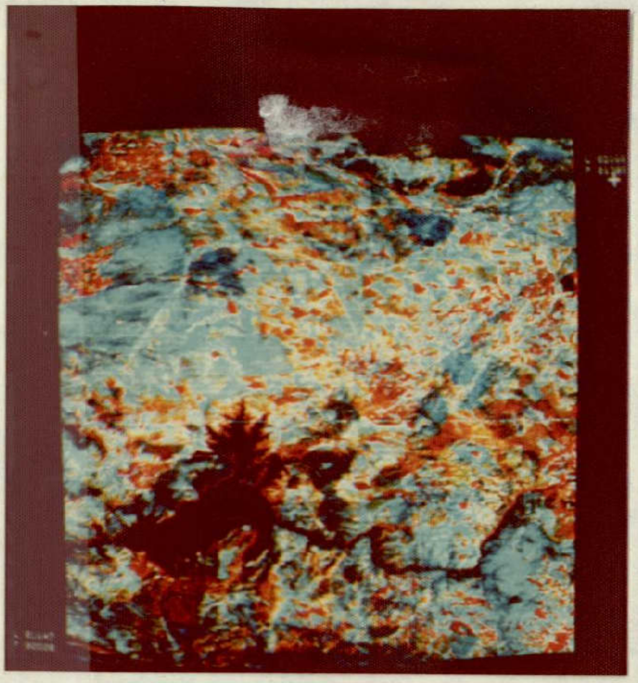


Figure 8

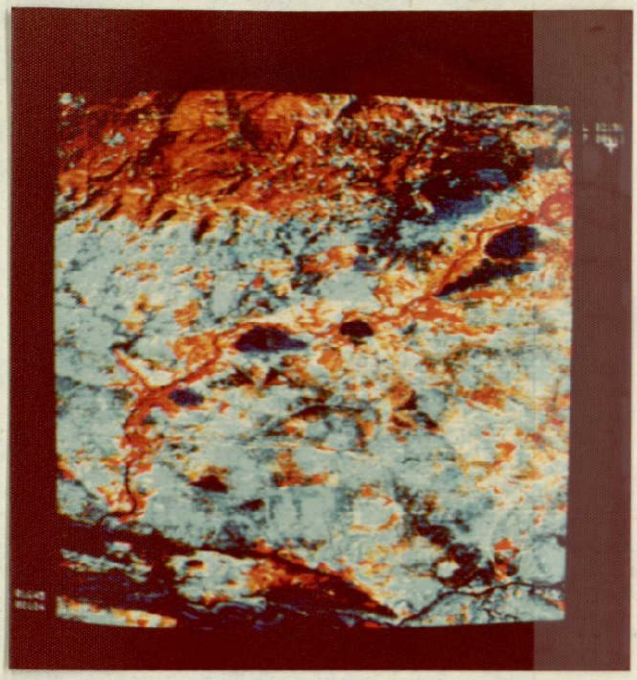


Figure 9

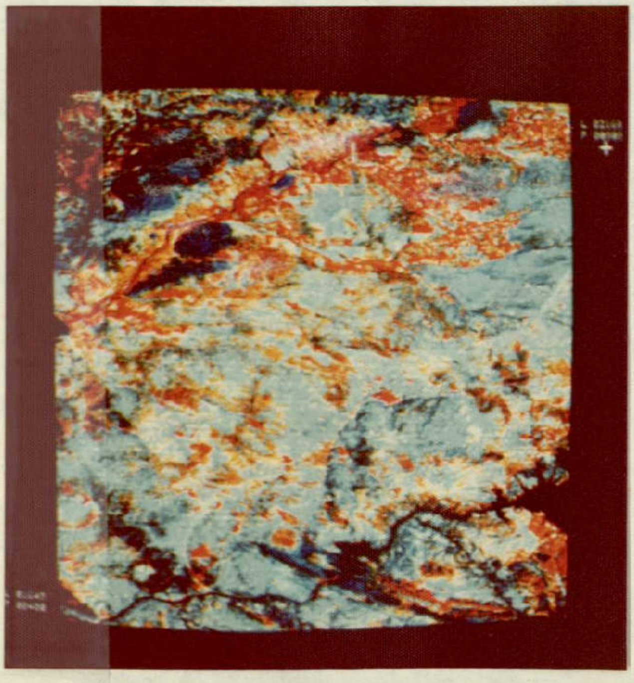


Figure 10

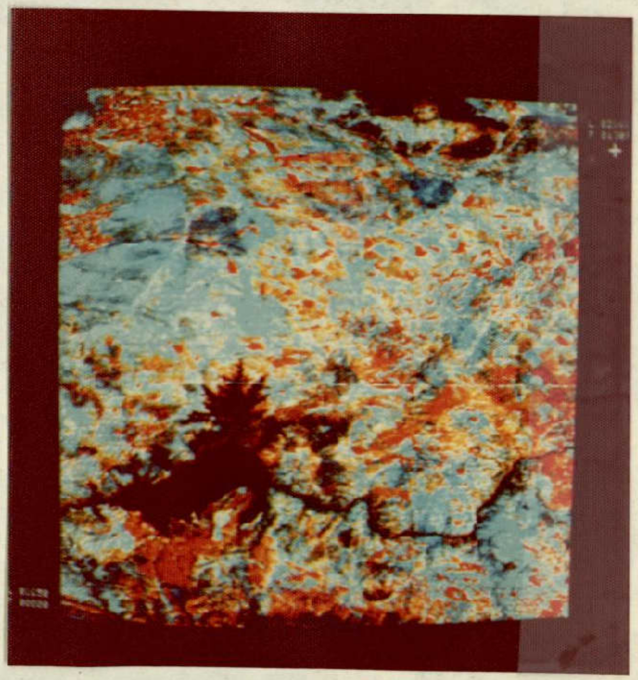


Figure 11

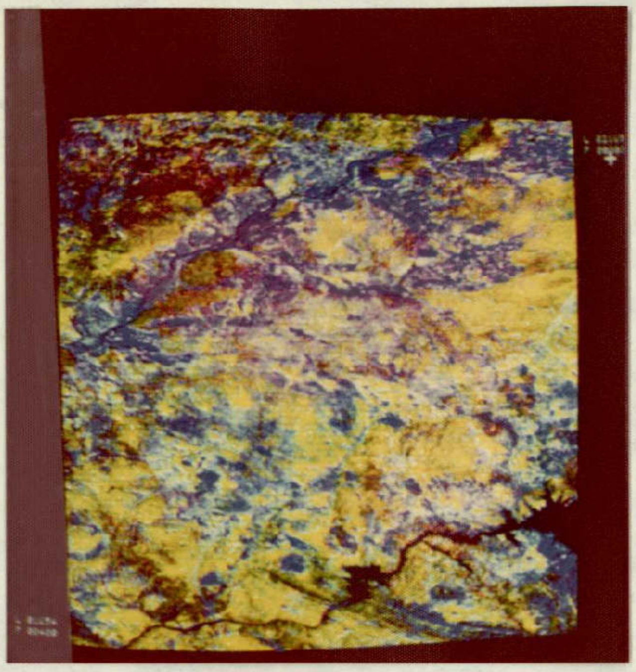


Figure 12

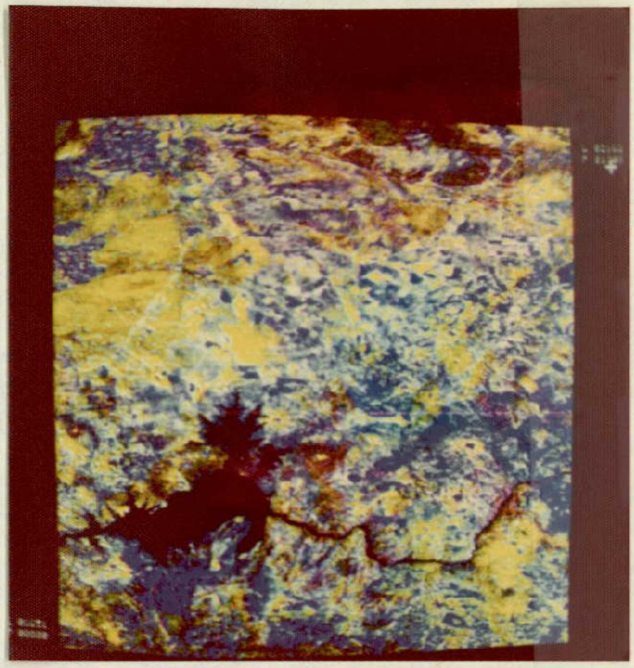


Figure 13

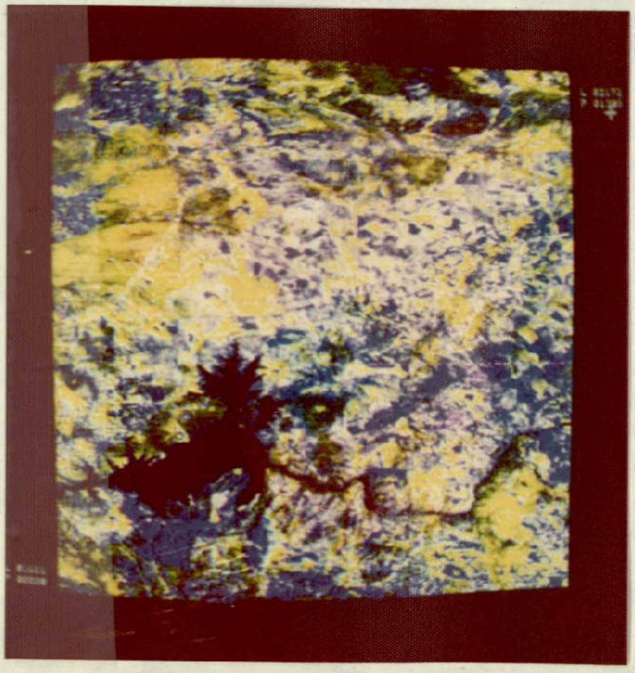


Figure 14

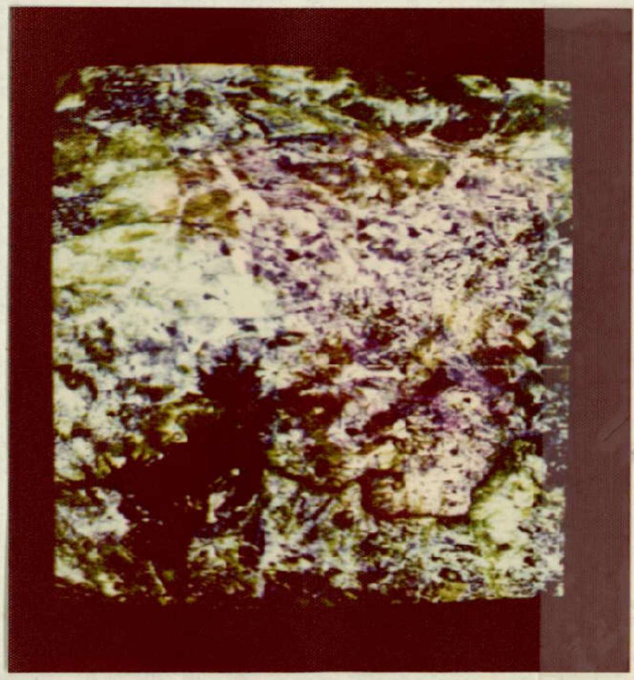


Figure 15

-d) R 5/4 G 7/4 B 7/5 (fig. 9,10,11)

given by:

R $I'_6=32\ I_5/(I_4+1)$

G $I'_{14}=64\ I_7(I_4+1)$

B $I'_{15}=64\ I_7(I_4+1)$

This last was indicated by Short et al. (1975), in the differentiation of rock-types with a different grade of alteration of the iron contained, commenting upon its great sensitivity to vegetation types.

-e) R 5 G 7 B 7/5

given by:

R $I'_5=I_5$

G $I'_{13}=I_7$

B $I'_{15}=64\ I_7/(I_5+1)$

Other combinations may also be considered acceptable, but are not as clear as the former:

R 7/6	G 6/5	B 5/4	(Fig. 12, 13)
R 7/4	G 6/5	B 5/4	(Fig. 14)

Cited by Blodget et al. (1975) as very appropiate for lithological differentiations in volcanic areas.

It is fitting to emphasize the existence of those which are especially indicated for contours of non-linear structure (folds), not being valid for the observation of linear elements:

R 4	G 7	B 4/7	
R 5	G 7/4	B 7/5	
R 7/4	G 7/5	B 7	(fig. 15)
R 7	G 7/4	B 7/5	
R 5	G 7	B 7/5	

The remainder of ratios are not suitable for geological purposes. We ought to indicate the absence in the majority of them of band 6, which incurs unacceptable noise levels.

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The coefficients given (I'), are those used by us to obtain a projection of results at 8 bits.

II.4.- Conclusions

Starting from the prior knowledge of the zone and as result of the cited analysis we can enumerate the following conclusions:

- For each area of work and according to the type of objectives proposed the most appropiate ratios will have to be sought, those cited by other authors serving solely for reference purposes.
- The northern border of the "Campo Arañuelo Basin" is clearly defined in all instances.
- The southern border may be confused, in many cases, with the colour of the tertiary covering material and its limit must be established from linear structures in the ratios which they emphasize. These structures are the inverted faults cited in ch.I (fig. 2).
- The folding structures of "Montes de Toledo" stand out as such in all the ratios.
- There is not possible differentiation between igneous and metamorphical rocks in the units of basement which limit the Basin to the south except when an accentuated topographical difference is implicit.
- In the ratios cited as optimum the limiting fractures of the units appear with great clarity, likewise those which are to be found in the interior of the blocks of sufficient proportions.
- For reasons of scale, lines observed as singular may correspond to various fractures in the terrain, by longitudinal continuation or by assimilation due to lateral proximity.

- The possibility of indicating lithological changes in covering material does not exist in any ratio.
- The terrains which possess considerable quantities of quaternary material and the major river-beds also show up in all cases because of their low reflectivity.
- In many instances, somewhat less lines can be observed in the covering zone, which, by their characteristics, must indicate a reflection of fractures in the underlying basement.

20a

FRACTURE PATTERN IN CENTRAL IBERIAN PENINSULA FROM LANDSAT

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SPAIN

I. INTRODUCTION

Fracture patterns from LANDSAT multispectral images are presented. Both advantages and inconveniences of these images are pointed out. In this work, only visible linear elements in the images are taken into consideration. These elements, in general, represent faults or fractures of the Hercinian socle. This report is submitted as part of the project no.28760.

II. FRACTURATION MODEL

A series of geological studies is been carried out by investigators of the Cátedra de Geodinámica Interna of the University of Madrid, as participants in the project, using LANDSAT multispectral imagery obtained over Central Spain.

Images used for this work were obtained by LANDSAT-1 on March 1973 (E-1228-10325, E-1229-10384 and E-1227-10271), in bands 5 and 7 at scale 1:1.000.000 (fig. 1 and 2), and by LANDSAT-2 on July 1975 (E-2170-10204) in bands 4, 5, 6, and 7. A color composite was also available at scale 1:500.000.

The selected area for establishment of a fracturation model belongs to the Central Spanish System, which geologically is formed by the Hercinian socle metamorphic-granitic of the Hesperic massif (fig. 3 and 4). North and South of this mountainous chain extend the tectonic basins of Duero and Tajo respectively, which are covered by tertiary sediments. Located in the bords of the mountainous system appear some mesozoic materials (Cretaceous).

Figure 1.—Mosaic of LANDSAT images over Central Spain

20c

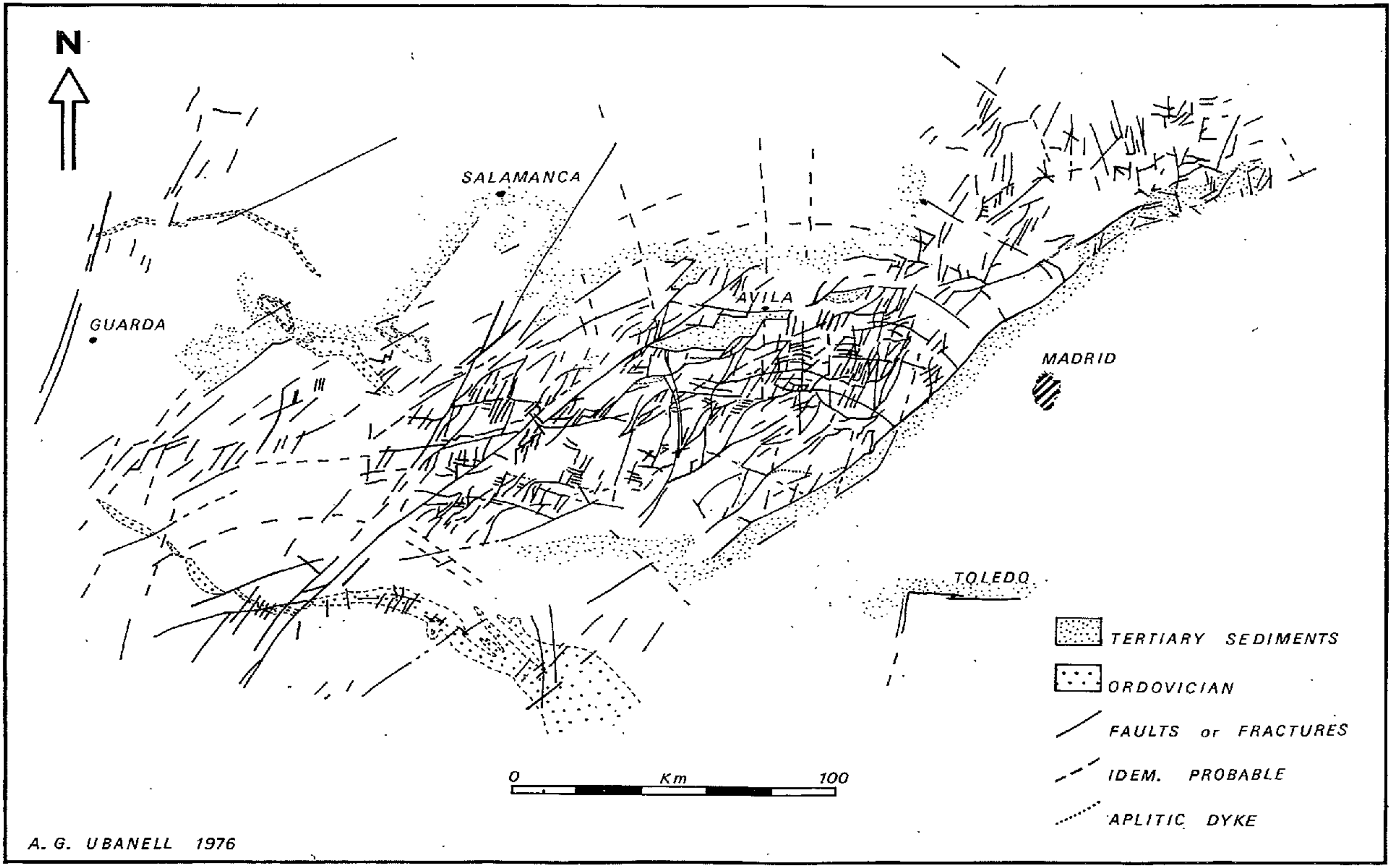


Fig. 2

FOLDOUT FRAME 1

FOLDOUT FRAME 2

This area was selected because it is an old cratonic massif in which fracturation, after orogenesis, is well seen were the socle outcrops. In places were it is covered by tertiary materials it can also be determined a certain type of fractures and morphotectonic accidents.

The main fracturation was developed in the late Hercynian time (Parga 1969), producing strong sinistral wrench faults (Artaud et Matte 1975), and dextral also (Ubanell 1975) in NE-SW direction. Subsequently, in the Alpine times, much of these faults operated again. Some of these elements reach a megastructure scale, as the big diabasic dike of Alentejo-Plasencia (Figuerola et al. 1973), with a length of 500 kms.

The statistical study of the directions of fracture is in Bischof 1975. We only treat the accidents appertaining to the best studied directions.

III. FAULTS NE-SW

Analysis of figures 1 and 2 shows that main faults correspond to the wrench NE-SW alignement, being the stated dike of Alentejo-Plasencia and the southern fault of Spanish Central System the main fractures. The first is a late-Hercynian fracture refilled with the diabase currently constituting the dike, with a Structural evolution very complex. Dextral movements were detected (Ugidos 1974), but in aerial images is easier to recognize the sinistrals, as it can be seen on the Ordovician band, which is folded.

It can be observed in the LANDSAT image that dislocated ordovician materials, to the W of the mentioned fault, are better noticed than in the E. Dislocations are produced in straight lines on the West side, while the eastern side forms an arching of the structure. This arch allows the statement of the hypothesis

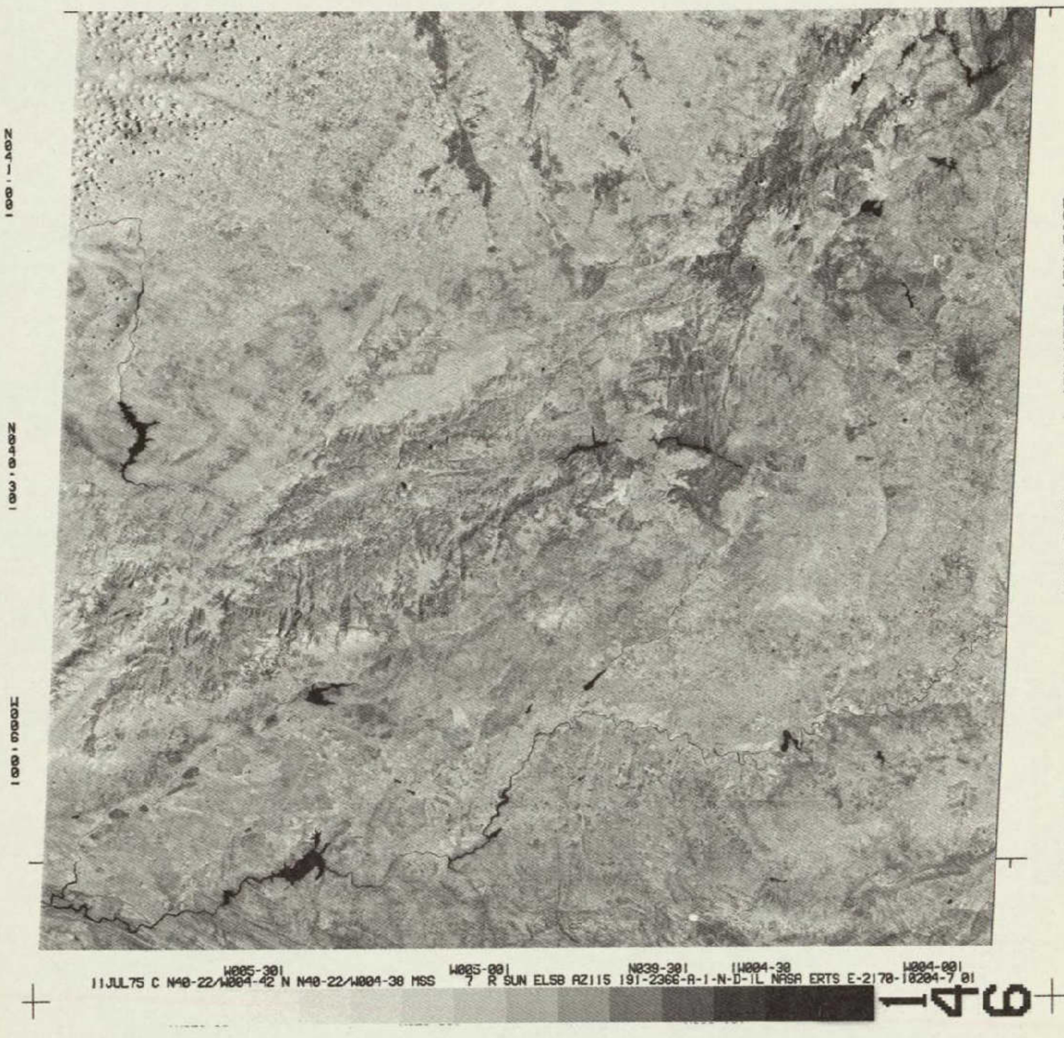
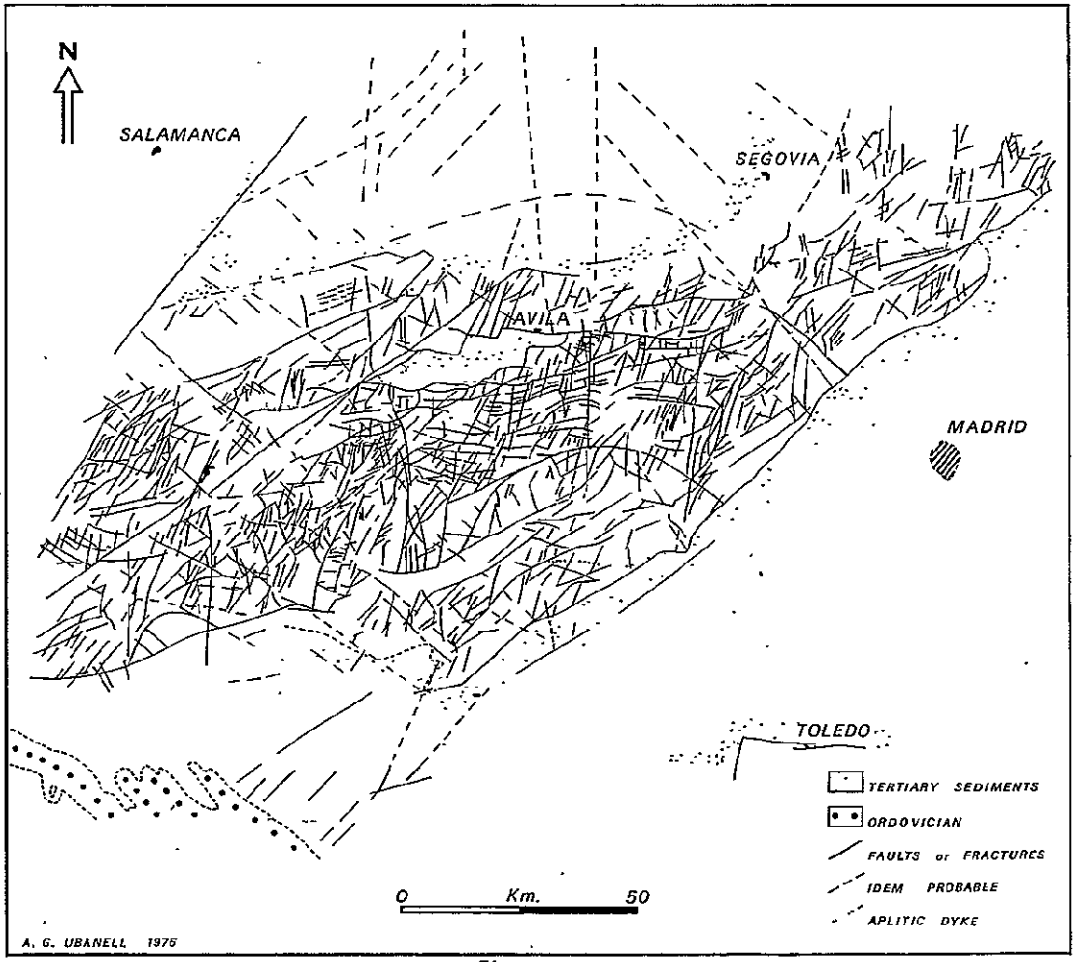


Figure 3.—LANDSAT image no. E-2170-10204

21 B



N
SALAMANCA
SEGOVIA
AVILA
MADRID
TOLEDO
TERTIARY SEDIMENTS
ORDOVICIAN
FAULTS or FRACTURES
IDEM PROBABLE
APLITIC DYKE
0 Km. 50
A. G. UBANELL 1975

Fig. 4

of "displacement towards the East of the line of fault of the fault of Alentejo-Plasencia". Like this can be established the existence of a perpendicular compression to this great fault, synchronic with the sinistral movement, causing this wide curvature (fig. 5); which means an effort in approximative direction N-S. Compression in the NW-SE direction produces a displacement of the line of fault towards SE in 8-9 kms. Neat displacement of geological units in both sides of the fault is 4-5 kms., but considering the arch effect, the real displacement can be established as been of 23 kms.

The other important accident with this same direction is constituted by the southern bord of the Central System, which actually is a contact with the tertiary depression of Tajo river by means of a reverse fault. In the late-Hercynian times has acted primarily as dextral wrench fault and later as sinistral. In the Alpine times has moved as reverse fault mounting the Miocene sediments. Finally, several quaternary movements have been signaled at this unit by Pedraza Gilsanz (1976).

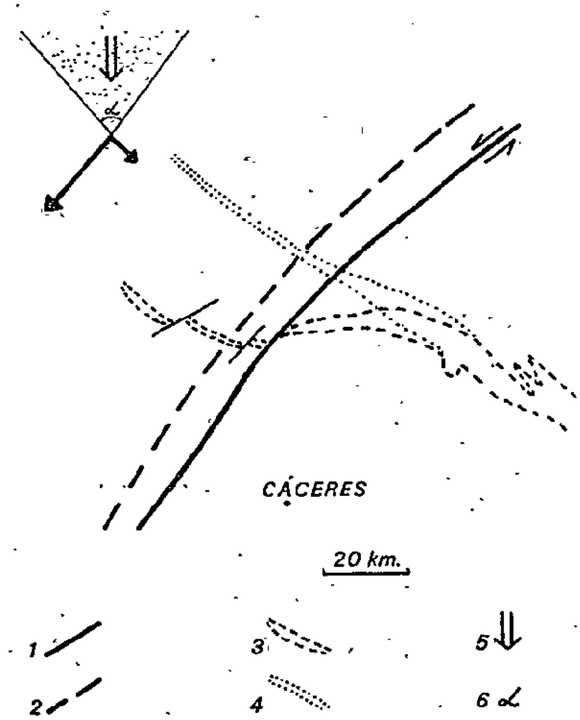


Figure 5

1. Actual position of Alentejo-Plasencia fault
2. Initially suspected position of the fault
3. Actual position of ordovicic materials
4. Initially suspected position of such materials
5. Direction of efforts
6. Incident angle of efforts

(black arrows show displacement vectors).

These two great tears are first order elements developed at Peninsular scale (Vegas 1974, 1975). Parallel to them exists a system of minor faults of great importance.

IV. FAULTS NW-SE

They form a conjugate system with the mentioned above, of minor development. Anyway, to the North, out of the image, this system is conditioning the geological structures (Martinez Alvarez 1974).

V. FAULTS N-NE

Because sinistral movement of the NE-SW faults the tension fractures N-NE are produced, which frequently are quartz filled; in comparison with the NE-SW faults they are not so long but appearing very often.

VI. FAULTS E-W, N-S and other

East-West fractures had a great influence in the geological evolution of the region (Alía Medina, 1972), resulting visibles in the contact between the metamorphic-granitic socle of Toledo, as well as in other places of Central Spain. North-South faults are noticed by their continuity in the tertiary materials, with recent movements.

VII. CONCLUSION

Multispectral images taken by satellite are very useful for establishing a fracturation model at regional scale, but it is always required for a perfect knowledge of such a model to use traditional investigation techniques by means of field work.

PARTICIPATION OF CENTRO DE ESTUDIOS HIDROGRÁFICOS IN LANDSAT-2 INVESTIGATION PROJECT

By Centro de Estudios Hidrográficos
Ministerio de Obras Públicas
Madrid-5
SPAIN

I. INTRODUCTION

Investigations carried out by Centro de Estudios Hidrográficos are located in the area selected for hydrology in NASA project no.28760. This area, limited by coordinates W002º31' - W004º31'/N39º40' - N41º20', is covered by two LANDSAT-2 images. Studies have been done with LANDSAT-1 images no. 1228-10325 and 1227-10315, which were available on magnetic tape. Two LANDSAT-2 images (no.2170-10204 and 2187-10143) have also been used in slides and paper prints.

II. TECHNIQUES

Because repetitive coverage over test site was not available, evolution processes could not be envisaged until the moment in this project. Treatment of the information was done only with images showing a character of permanency, not depending on the geographic location of fenomena. These studies concern two main subjects:

1 - Renewal of hydrographic cartography
2 - Terrain classification in hydrographic basins.

The first subject is been done by means of the color composite viewer, showing false color images at scale 1:500.000. Hydrographic network, reservoirs and lakes can be identified in each spectral band or as combination of them. Drawing of these items is done on transparent polyester.

Another approach to this objective is application of geometrically corrected images to the computer for automatic classification. Results can be converted into image by the DICOMED film recorder. Expected cartographic accuracy is equivalent to a 1:200.000 scale. This work is done in contact with Instituto Geográfico y Catastral, and geometric correction software is available from IBM Investigation Center of the Autonomous University of Madrid.

Terrain classification has been started in contact with IBM Investigation Center, using an interactive television terminal RAMTEK. Digitizing of hydrographic basins was done with a DMAC digitizer, for superimposing these data on magnetic tape to LANDSAT-2 satellite imagery. The program used for this includes a coordinate transformation in order to position LANDSAT image and basin boundaries in the same projection. Terrain classification with ERIPS program allows differentiation of natural indicators of soils related to surface drainage. Classes used are the following:

a) soils without vegetative coverage
b) fall vegetation
c) perennial vegetation
d) crops
e) prairies
f) water

Several subclasses could also be differentiated in relation to soils, rock type and vegetative coverage, but patterns mentioned above seem to be good indicators of surface drainage. Some field work will be done for checking the classification. In any case, only well known basins will be studied on this project.

III. ACCOMPLISHMENTS

Digitizing of hydrographic basins boundaries is done on polyester at scale 1:500.000. Surface measurements in reservoirs, through RAMTEK terminal, show a good relationship between areas obtained in the computer and real data available from the date of LANDSAT observation.

IV. PROBLEMS

This work has been retardered because two LANDSAT images (no. 2170-10204 and 2187-10143) were not available on magnetic tape. Request has already been done to NASA, through EROS Data Center, concerning this subject.

Vegetation, snow and crop measurements can not be done unless repetitive coverage every 18 days is obtained.

V. DATA QUALITY

Enlarged B&W paper prints supplied by Instituto Geográfico y Catastral do not show the full range of gray levels, because original 70 mm negatives have sometimes a hard contrast which makes difficult to differentiate half tones.

VI. CONCLUSSIONS

The investigation team of Centro de Estudios Hidrográficos intends to attend very useful results in terrain classification and renewal of hydrographic basin cartography; which can be done in a short time with LANDSAT images.

FIRST PHOTOINTERPRETATION RESULTS OBTAINED FROM LANDSAT-2 IMAGES FOR SOILS INVESTIGATION.

By Dr. Francisco Monturiol
Instituto de Edafología
Consejo Superior de Investigaciones Científicas
Madrid
SPAIN.

I. INTRODUCTION

The purpose of this investigation is evaluating the possibilities of the information supplied by LANDSAT-2 for soils studies. Images have been related to the results of several works carried out in the field by investigators of the Soils Department of Instituto de Edafología (C.S.I.C.). This report is submitted as part of the project no.28760.

II. REPORT

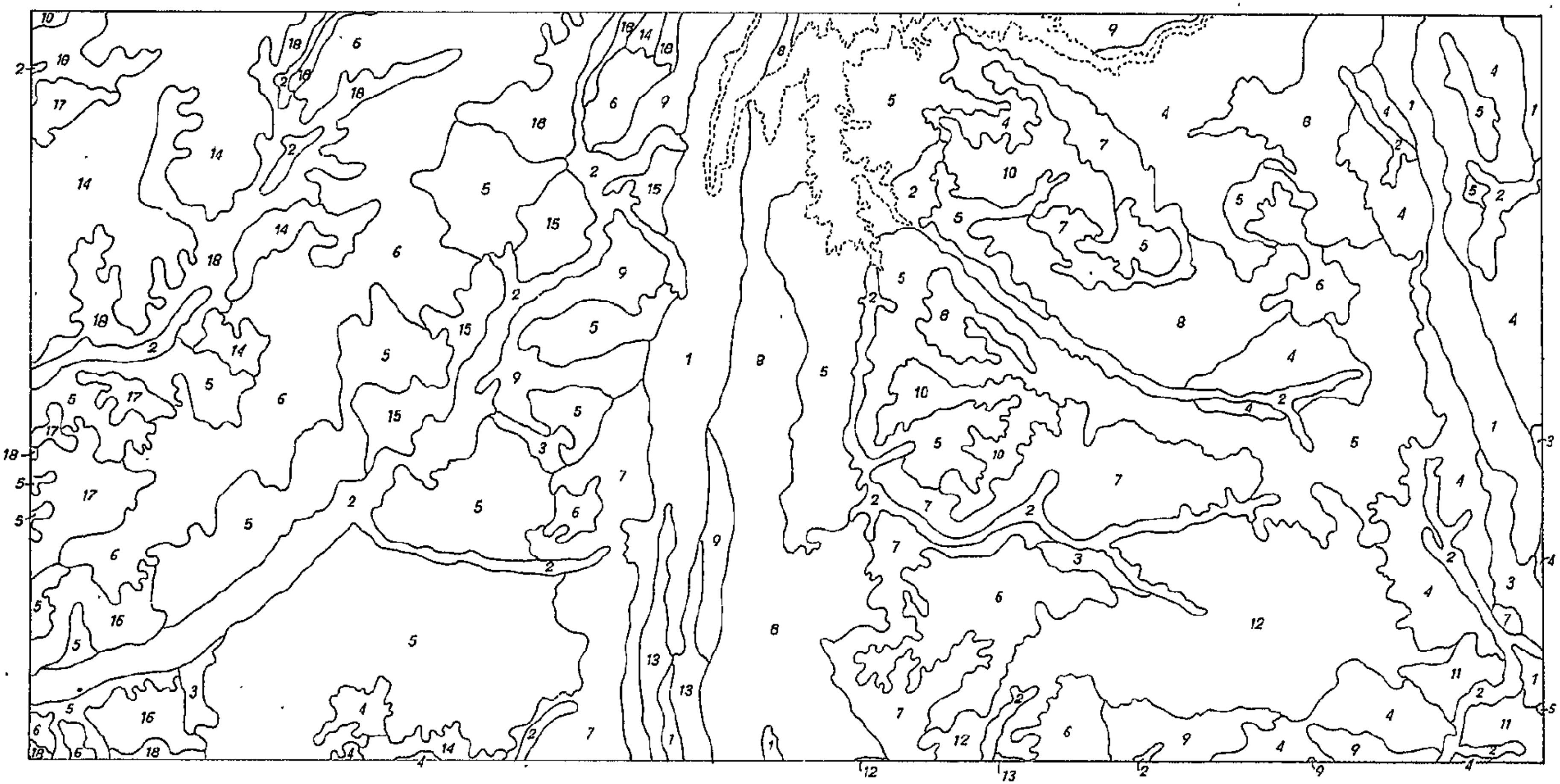
The area of investigation is approximately 5.000 km^2, located in the confluence of Guadalajara, Cuenca and Madrid provinces, corresponding to coordinates: N40º00-N40º40'/W3º30'-W2º07'. This area offers a variety of physiographic units and soils, and that is the reason why it was selected. The main relief forms are the following:

1 - Alluvial valleys mainly along Tajo and Tajuña rivers, as well as along some other tributaries of them.

2 - Areas characterized by clay soils of variable depth, containing sometimes accumulation horizons of calcic carbonate.

3 - Areas of smooth hills and colluvial valleys characterized by soils of medium texture.

4 - Hills and mountains formed by a variety of lithological materials, mainly limestones of variable composition and calcaric sandstones.



SOIL MAP. SCALE 1 : 400.000

Figure 1

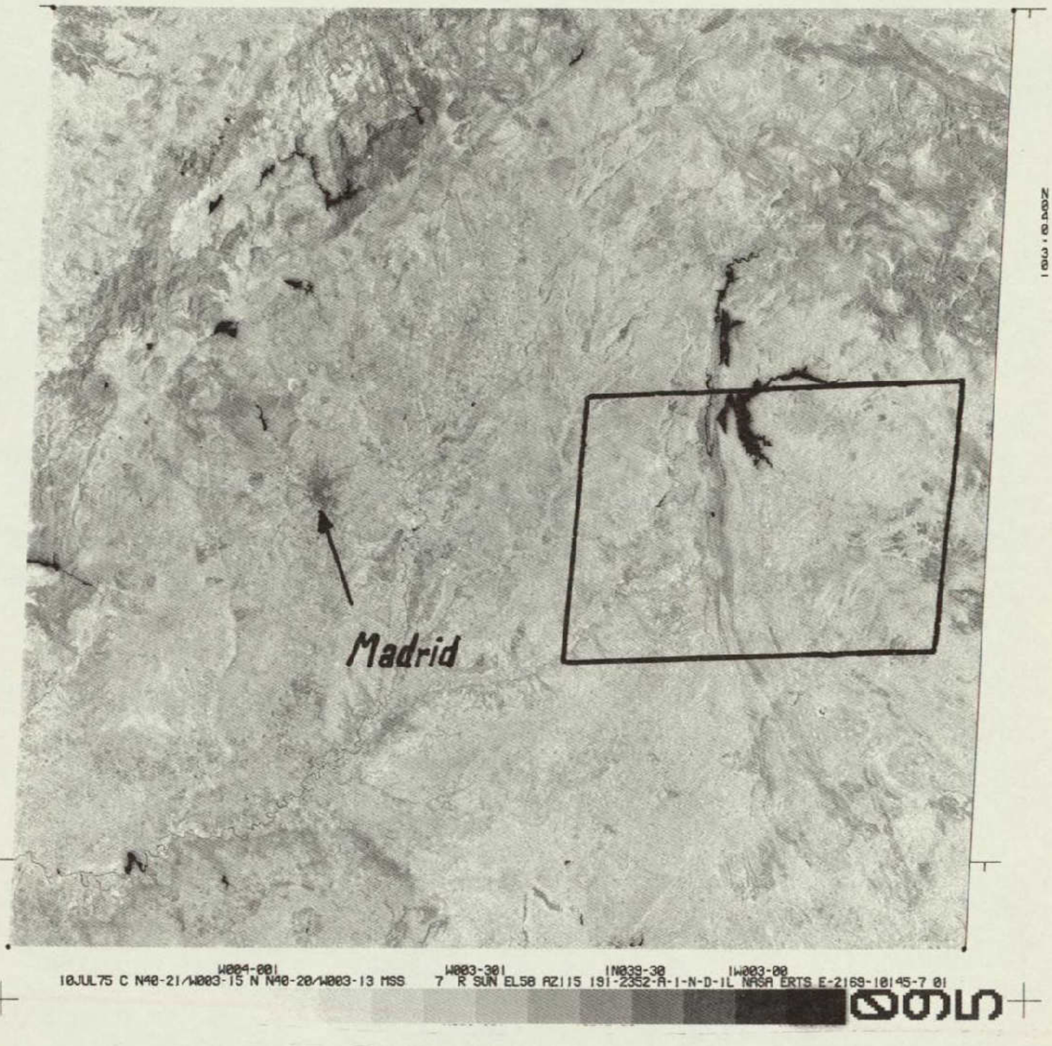
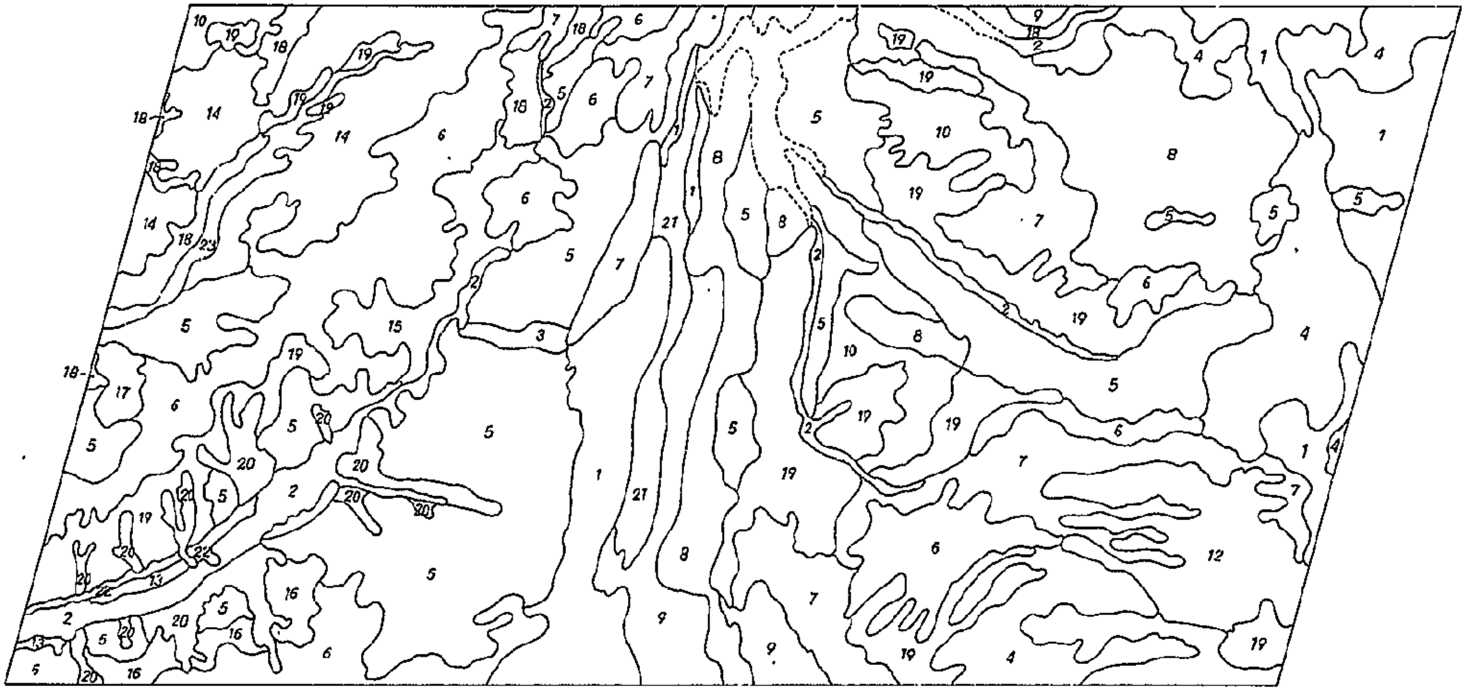


Figure 2.—LANDSAT image no. 2169-1045 and location of test-site



SOIL MAP OF LANDSAT-2 IMAGE NO. 2169-10145 OBTAINED BY PHOTOINTERPRETATION OF BAND 7.

Figure 3

The more important units from an agricultural point of view are the alluvial valleys, colluvial valleys and soils of heavy texture. Preliminary work was done by conventional photointerpretation using black & white paper prints with field check. In the first phase of the work black & white iamges were used at scale 1:1.000.000 studying photographic quality of the information, resolution and various aspects of different soils in each band. Field work over test site was done following intineraries along existing communications network, investigating appearance of each soil unit mainly considering resolution and influence of certain elements as vegetative cover, drainage patterns, erosion, land use and frecuency of rocky outcrops.

Four LANDSAT-2 images were available corresponding to bands MSS 4, 5, 6 and 7. Band 4 was not very useful because low detail resolution due to atmospheric scattering. Almost all existing forms of terrain have been detected in other bands.

Band 5 seems to be the more influenced by rock colors and bands 6 and 7 present high effect of soil moisture and vegetative coverage. Roads and urban settlement were clearly detected on band 5, as well as water flows in bands 6 and 7.

Resolution of bands 5, 6 and 7 was similar, which allowed superimposing interpretation results of band 7 to transparencies obtained from band 6.

By comparison of existing aerial photointerpretation works at scale 1:400.000 (fig.1) with LANDSAT-2 image no.2169-10145 (fig. 2), a map of soils was drown at scale 1:500.000 in band 7 (fig. 3). Finally, tables 1 and 2 show the legends for interpretation of both maps.

TABLE 1. LEGEND OF SOIL MAP AT SCALE 1:400.000 (F.A.O. System)

no.	Soil association	Inclusion	Topography	Orogenic Material
1	Rendzina-Lithosol	Calcil Cambisol	Rolling	Limestone
2	Eutric Fluvisol-Calcaric Fluvisol	--------	Smooth	Alluvium
3	Calcaric Regosol-Vertic Cambisol	--------	Smooth	Alluvium and colluvium
4	Calcic Cambisol-Calcaric Regosol	Redzina	Ondulating	Calcaric sandstone
5	Calcaric Regosol-Calcaric Fluvisol	Lithosol	Ondulating	Gypsum
6	Calcic Cambisol-Chromic Luvisol	Vertic Luvisol	Smooth	Limestone and loam
7	Calcic Cambisol-Lithosol	--------	Ondulating	Sandstone loam and gypsum
8	Calcic Cambisol-Redzina	--------	Smooth	Loam, limestone and gypsum
9	Eutric Cambisol-Eutric Regosol	Lithosol-Vertic Cambisol	Ondulating	Sandstone, loam and conglomerate
10	Calcic Cambisol-Orthic	--------	Smooth	Gypsum and silex
11	Calcic Cambisol-Eutric Rogosol	--------	Ondulating	Calcaric sandstone
12	Eutric Cambisol-Calcaric Regosol	Lithosol	Rolling	Loam and sandstone
13	Calcic Cambisol-Calcaric Regosol	--------	Smooth	Colluvium

no.	Soil association	Inclusion	Topography	Orogenic Material
14	Chromic Luvisol-Calcic Cambisol	Orthic Luvisol	Smooth	Limestone
15	Calcic Cambisol-Calcic	--------	Smooth	Detritric sediment in glacis
16	Calcaric Regosol-Calcic	--------	Smooth	Eolic slime
17	Calcic Luvisol-Calcic Cambisol	--------	Lightly ondulating	Detritic sediment
18	Calcic Regosol-Redzina	--------	Rolling	Alluvium slope

TABLE 2. LEGEND OF SOIL MAP OF FIGURE 3

This map has repeated 18 associations appearing on the soil map at scale 1:400.000 and, furthermore, the following new associations are included:

no.	Soil association	Inclusion	Topography	Orogenic material
19	Calcaric Regosol-Lithosol	----------	Rolling	Gypsum
20	Calcaric Regosol	----------	Rolling	Gypsum loam
21	Eutric Regosol-Dystric Regosol	Calcic Cambisol	Rolling	Loam and clay
22	Lithosol	Rendzina	Rolling	Gypsum
23	Calcaric Regosol-Calcaric Fluvisol	----------	Smooth	Alluvium and colluvium

LAND-USE CLASSIFICATION OVER CENTRAL SPAIN FROM LANDSAT-2 IMAGERY

By Elena Chicharro
Instituto de Geografía Aplicada
C.S.I.C.
SPAIN

I. INTRODUCTION

Land use schemes and hydrographic network presented correspond to an area of 2.000 km^2, located in the Sierras of Guadarrama and Somosierra, with coordinates W3º11'-W3º51'/ n40º40'-n41º00'. This is a test site on which has been elaborated and corrected the land use classification after checking by field work, and which will be used extrapolated for the analysis of the Central Region of Spain.

The above mentioned area covers four sheets of the National Topographic Map at scala 1:50.000 (no.484: Buitrago de Lozoya, no.485: Valdepeñas de la Sierra, no.509: Torrelaguna and no.510: Marchamalo), and presents a variety of land use classes related to well known physiographic units.

In the Sierras can be identified surfaces dedicated to forest and bush, in the hillsides the pastures, and in the Miocene materials of detritic nature the cereal crops and uncultivated lands could be recognized.

In this first report of land use classification, based on information obtained by LANDSAT-2 satellite, it is intended to verify its guaranty by comparing enlarged black and white paper prints at scale 1:500.000 with ground truth already available and aerial stereoscopic images at 1:33.000 and 1:15.000 scale.

Magnetic tapes of the area were not yet available when this report was submitted, but digital processing will be used in the future for land use classification over Central Spain.

II. METHODOLOGY

The 1:500.000 scale is very indicated for a regional analysis, but it cannot give a precise view of land use classes covering small surfaces but with estimable economic value (p.e. local irrigation network).

NASA LANDSAT image no.2169-10145 (figure 1), taken in July 10, 1975, has band 5 as the best for interpretation purposes and accuracy in delineation of land use boundaries (figure 2). Forest features are easely identified, specially coniferous trees, and some other species. There is a difference in tonality between developed pines and pines of recent reforestation, which can be recognized if they cover a large area. Differentiation of species is impossible in mixed forests.

A characteristic gray tonality allows identification of bush, which is intermediate between coniferous trees (dark gray) and uncultivated lands (light gray), been easely confused with other types of forest. Two different types of pastures and prairies have been identified; those presenting trees in the interior or contour of the parcel and those without them. In any case, uncultivated lands have a tendency to be confused with pastures.

Cereal crops in dry land are well detected by a characteristic light gray tonality, and two different subclasses can be recognized depending on size of the parcels: with recent parcel concentration or with fractionary cultures. Finally, irrigated lands present near rivers a dark gray tone which makes their pattern unmistakable.

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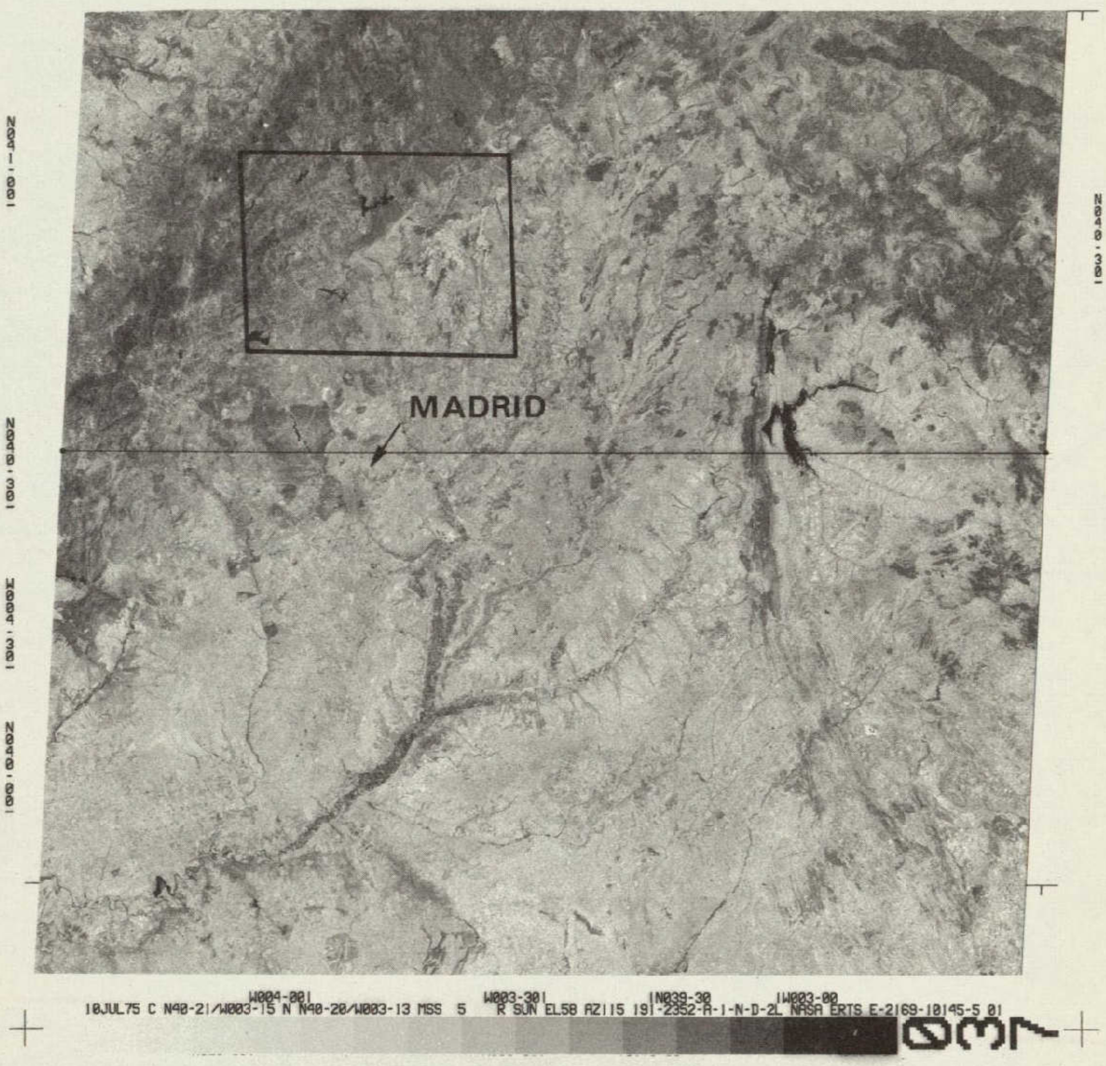
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10JUL75 C N40-21/W003-15 N N40-20/W003-13 MSS 5 R SUN EL58 AZ115 191-2352-A-1-N-D-2L NASA ERTS E-2169-10145-5 01

Figure 1.

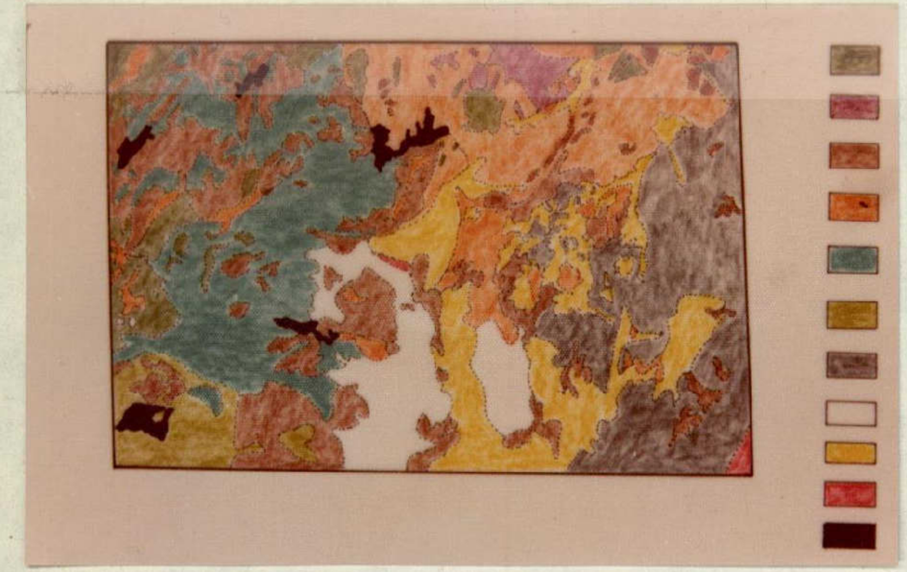

Figure 2. Land use map of image nº 2169-10145-5

Coniferous forests

Coniferous of recent reforestation

Other forests (oak grove, holm oak, etc.)

Heaths

Pasture fields with trees

Pasture fields without trees

Uncultivated land

Mixing cereal and uncultivated land

Cereal cultivated dry land

Irrigated land

Reservoirs

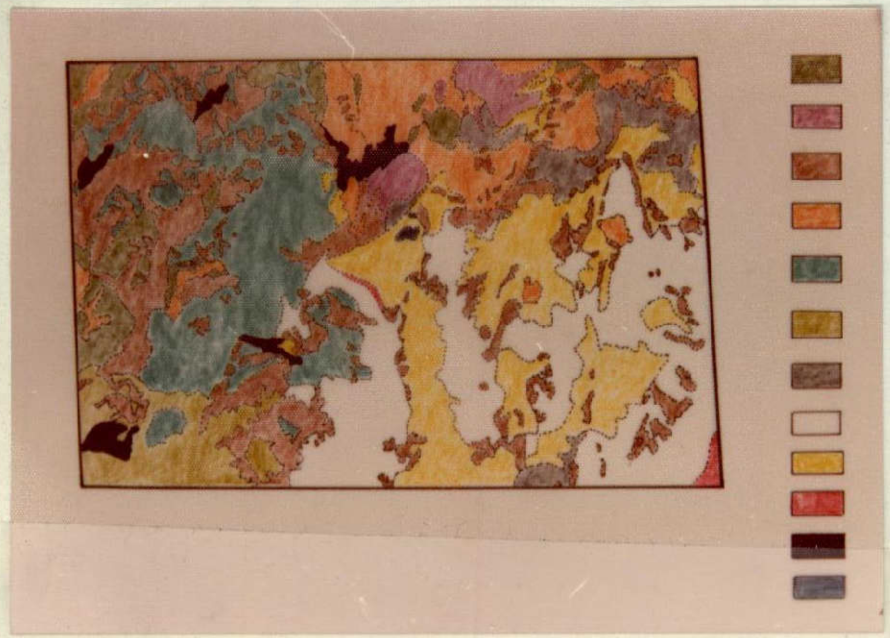

Figure 3. Land use map of image nº.2169-10145-4

Coniferous forests

Coniferous of recent reforestation

Other forests (oak grove, holm oak, etc.)

Heaths

Pasture fields with trees

Pasture fields without trees

Uncultivated land

Mixing cereal and uncultivated land

Cereal cultivated dry land

Irrigated land

Reservoirs

Vineyard

It has been impossible to detect shrub crops (olive grove and vineyard) because their location in small areas; only when vineyard appeared with developed foliage (July and September), surrounded by cereal crops of lighter tone, it was possible to identify this crop clearly.

Band 4 offers in land use classification minor possibilities of interpretation (figure 3). Boundaries of forest are more undefined in this band, which makes difficult a land use map drawing. A total of 12 classes could be distinguished on band 5 by photointerpretation techniques and supervised field work.

Bands 6 and 7 do not offer in general good possibilities for land use analysis; only reservoirs and waterflows are better observed than in band 4 or 5. Band 6 has been used on this work for delineation of drainage patterns and establishment of a relationship between them and land use classification units.

Comparative analysis of bands 5 on images obtained in July 10-1975, July 28-1975, September 2-1975 and January 24-1976, showed that more clear details and a better land use classification can be obtained from the image dated September 2-1975. Phenological state of crops by January 24-1976 did not allow obtaining good results by photointerpretation techniques. Only perennial species of coniferous trees and holm-oak groves could be identified.

GEOMORPHOLOGICAL INTERPRETATION OF LANDSAT-2 IMAGES OVER CENTRAL-WESTERN SPAIN

By Juan José Sanz
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I. INTRODUCTION

This report is result of the analysis done with several LANDSAT images over Central-Western Spain, corresponding to the area of Sierra de Gredos until the frontier of Portugal. Enlarged black and white paper prints were also available in bands 4, 5, 6 and 7 of image no.2171-10262, taken in July 12, 1975, representing the Southern part of Salamanca and Cáceres provinces, and northern part of Toledo and Avila. The basic configuration of this image is represented by the Central System and Duero basin.

II. GEOMORPHOLOGICAL INTERPRETATION

Several bands have been considered for this work, being all of them influenced by the reproduction quality of the enlargement at scale 1:500.000. Bands 6 and 7 have been selected for identification of relief, water run and geomorphology. Low contrast of bands 4 and 5 make them useful for our purposes in recognition of open areas in Alpine vegetation and great cattle paths over socle.

This work applies some conventional photointerpretation techniques which allow identification of anomalies like the asymmetry of Tietar river, with the right margin run by mountain streams and plain affluents coming from the left side. Color materials and rocks are good indicators of lithology because tehir dark gray tonality appearing on the images. For land use

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LANDSAT image n. 2171-10262 in band 7

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studies, we take vegetation as indicator. In general, a relationship can be stablished between a change in rocks and the vegetation related to the soil. This has been noticed in the pine groves along Tietar river, which are associated to alluvial materials. Drainage network has also been taken into consideration for elaboration of the following classification:

- schists, appearing dark and strongly divided. Only a high contrast of relief allow their identification.
- continental sandstones from Eocene times, which produce wide rambles appearing also under lowland cover. Good examples of this type can be found in Huebra and Yeltes rivers.
- whitish corridors of tectonic origin, represented by fractures and alignements characteristic of granite and their orthogonal network. In Sierra de Gredos they can be confused with different rocks.
- lengthened serpentines, with layer lines and forestation peculiarly from quartzites.
- high Tertiary materials, with continental sediments and sandstones, limestones, gravels and quaternary fluvial terraces.
- lowlands can be identified by the hydrographic network of radial pattern.

Megastructure features and alignements are an important part of this identification which calls the attention of some investigators. A main NE-SW direction is shovn in the image, being represented by the Jerte fault; a line of weakness at national scale. Bejar corridor, a caved voussoir between the granitic Sierras and the quatzitic Hurdes formations, has also that general direction. These are real morphotectonic lines of great importance, which are noticed only at a regional scale (the most difficult idea to obtain in conventional aerial

photointerpretation). Another interesing feature is the grave flanked by fractures replenished of Cenozoic deposits. They are in general associated to NE-SW faults in Eocenic materials.

Climatic morphology can be studied according to the fluvial network. Like this, it can be established the superimposition of Tajo river, with epigenesis on Tertiary showing rests in deeper sedimentary basins.

Glacier geomorphology is deduced from the presence of lakes in high mountains and the absence of vegetation in Alpine areas. Because the shadows appearing on scarps of trough valleys, tehir asymmetry is well remarked, mainly produced by glacier action, and their northern orientation.

LANDSAT-2 images will improve our current knowledge of surface features in Central Spain. As next step of this work will be accomplished a digital recognition of the area with magnetic tape.

V. PUBLICATIONS

The Teledetection Newsletter continues been published semimonthly, covering items of national interest on remote sensing.

A new publication has been finished at IGC, entitled: "La Teledetección y sus Aplicaciones Sociales".

VI. PROBLEMS

According to NASA conditions established for this project, images obtained by LANDSAT-2 over Central Spain after March 1, 1976 should be processed and supplied by Telespazio. Until the moment none delivery has been received from the Italian Station. It is expected to receive the images next June, and contacts between Telespazio and IGC have been established concerning this subject. Available images received from NASA during the last months are sufficient for development of the project. Supply of future images in June should be interesting for acquisition of ground truth reflected radiation data in real time, at the same hour of satellite overpass.

VII. DATA QUALITY AND DELIVERY

Last image supplied by NASA corresponded to March 1, 1976, and because the high cloud coverage present (30%), it was not processed and distributed to participating organizations. All other images furnished Since September 1975 for this project had good quality and maximum cloud coverage of 20%.

For delivery of images from Telespazio, a local contact in Rome has been designed, being the Air Attachee to the Spanish Embassy in Italy. From this point, information will be forwarded to the Space National Agency (CONIE) and distributed to the Principal Investigator.

VIII. RECOMMENDATIONS

From the point of view of spanish investigators no practical changes should be done in operations, and as NASA is concerned all data supplies were satisfactory.

IX. CONCLUSIONS

This project made possible to all participants the use of space acquired information for their own scientific purposes and applications. LANDSAT can be considered because this as a new instrument available to the national scientific community; but an instrument supplying continuous and repetitive coverage, in the same observation conditions, over remote areas, etc. It can be stated that nothing similar existed before and, furthermore, it has a continuity which guaranties to humans their right to observe the Earth from a panoramic point of view.

Experience obtained by participants in this project is encouraging new investigative efforts in the field of remote sensing and earth sciences. Considering that this technology was relatively new to spanish investigators, the advantage of using LANDSAT information has to be evaluated as a revolutionary discovery.